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Proposal to Build a Green Roof on Top of Hardin Hall on UNL's East Campus

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Proposal to Build a Green Roof on Top of Hardin Hall on UNL's East Campus

An Undergraduate Thesis Proposal

By Abbie Andersen

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Emphasis Area:

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Thesis Reader: Name: Christine Haney

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Abstract

The purpose of this study is to research the feasibility of implementing more green roofs around The University of Nebraska-Lincoln's campuses. To do this investigation a systematic literature review process was used gathering multiple relevant, peer reviewed articles from UNL's "Encore" search engine. The data was then organized into categories that described the necessary considerations that needed to be made to retrofit green roofs, information on their many benefits, and finally the potential energy cost savings that can be obtained through use of a green roof. From here a proposal for a model green roof on top of UNL's Hardin Hall building was created that UNL can utilize and adapt to retrofit green roofs around campus. It was found that this model roof would only cost $10.25 per square foot to build which is lower than the $14.50-$18.50 UNL typically spends per square foot to reroof its buildings. UNL could also benefit from seeing utility costs decrease as green roofs are able to reduce the amount of cool air lost from buildings in the summer and the amount of warm air lost form buildings in the winter. UNL can be leaders in green roof research, which will become increasingly important as global climate change becomes more severe and there is increased stress on buildings' heating and cooling systems. Green roofs also have the ability to reduce the urban heat island effect in cities, which will be important as urban expansion continues.

Introduction

This project proposes placement of a green roof onto one of the buildings on one of the University of Nebraska Lincoln's campuses. This work is important because green roofs can offer many benefits to the environment and to the urban area they're incorporated into. Lincoln has very few green roofs so UNL can lead locally in demonstrating their use and providing local green roof research sites.

Green roofs also offer the wider public benefits. For example, green roofs add ecological beauty to urban spaces, which in turn increases human interactions with nature and improves our sense of connectedness to nature (Sutton, 2014). Research has also shown that when office workers or students can look out over a green roof throughout their workdays, they become less fatigued and experience a reduction in stress, which allows them to be more productive (Sutton, 2015b). Because green roofs offer a system that infiltrates storm water , they slow and cleanse water runoff instead of letting that water go directly into storm sewers (Skabelund & Brokesh, 2013). The plants in a green roof system are also able to filter out atmospheric pollutants from the air and precipitation that would otherwise contaminate rivers and lakes (Sutton, 2015b). The photosynthetic cycles of plants allow for water to be evapo-transpirated. This factor combined with green roof plantings' elimination of large black roof membranes, helps mitigate the urban heat island effect and cool cities ("About Green Roofs", n.d.). Green roofs offer great opportunities for pollinators and bird with very limited habitat in highly urbanized landscapes (Skabelund & Brokesh, 2013). Utilizing otherwise wasted roof space to reestablish these habitats can increase ecosystem stability and diversity.

Green roofs offer private benefits to the building owners such as extending the life of roof membranes degraded by ultraviolet light and tearing from yearly heating and cooling. Green roofs are able to take a roof's 20-year lifespan and double it (Sutton, 2015b). Green roofs act as a protective barrier to these destructive properties ("About Green Roofs", n.d.) and eliminate re-roofing waste that would typically end up in a landfill after roof renovations (Sutton, 2015b). Green roofs also prolong the life of a building's heating and ventilation system because it reduces stress and use of these systems ("About Green Roofs," n.d.). A study done by the National Research Council of Canada found that the daily energy demand for air conditioning could be reduced by 75% in the summer for buildings that have a green roof ("About Green Roofs," n.d.). Finally, green roofs are able to increase a building's marketability ("About Green Roofs," n.d.) and its overall value.. This factor will increase as more cities begin to implement legislation that requires green roofs to be installed onto buildings in the future.

Many design factors need to be considered before a green space can be installed on top of a roof. First, structure, loading capacity and intended use will dictate green roof substrate depth. For example, extensive green roofs have lightweight substrate 2-6 inches deep, a semi-intensive green roof will have low to medium weight substrate that is 4.5-7.5 inches deep (Skabelund & Brokesh, 2013). Semi-intensive systems have the ability to support a larger diversity of plants like herbaceous perennials and shrubs, while extensive systems are more limited to lower-growing plant species (Sutton, 2015b). Extensive systems will require less maintenance than semi-intensive systems.

Green roofs can either be planned-out and built atop a brand new building or they can be retrofitted. Retrofitting establishes a green roof on top of a pre-existing roof structure based on the structural loading limitations of the roofs properties (Sutton, 2015b). In a study done in 2018 by Dr. Richard Sutton at the University of Nebraska Lincoln it was estimated that for new roofs adding 4 inches of media and plantings increases the structural cost by $33 per square foot (Sutton, 2018). As the depth of media and plantings increases to 8 inches the structural cost increases by $150 per square foot

(Sutton, 2018). It is also very important to consider the roofs slope, loading capacity, drainage system, and who (if anyone) will have access to the roof before choosing a location to build (“About Green Roofs,” n.d.). All of these factors can limit whether or not a green roof can be successfully retrofitted onto an existing roof.

Green roofs are not just made out of a layer of media underneath a layer of plants. To build a successful green roof ecosystem there are many components beneath the plants and media. On the top layer of the roof are the plants underpinned by the selected media, a drainage filter, a drainage layer, a root barrier, a waterproofing membrane and insulation and finally the roof’s structure (Sutton 2015b). All of these layers work together to maintain the necessary equilibrium plants need to grow while also protecting the roof.

After these considerations have been made, media and plant selection become keys to designing a successful green roof. The media used must be made out of organic and inorganic materials. The organic portion largely holds water and microbial populations while also supplying nutrients to the plants. The inorganic portion is used to provide structure to support plants and allow for rapid permeability of rainwater (Sutton, 2015b). The chosen media needs to supply nutrients to the plant while also providing water, gas exchange, drainage and structural support to the plants (Latshaw, Fitzgerld, & Sutton, 2009). Different options exist for green roof medias but typically they contain a mixture of heat-expanded shale, clay, perlite or other lightweight inorganic materials along with small amounts of organic matter such as local compost (Latshaw er al, 2009). The small, lightweight green roof located on top of the University of Nebraska-Lincoln’s

East Campus Rec Center utilizes shredded rubber from recycled tires as part of its inorganic structural component.

Plant selection depends on the climate, location, and condition of the roof that has been selected. One of the most fundamental factors to consider when picking potential plant candidates relies on tolerance to drought, wind, and heat stress (MacDonagh & Shanstrom, 2015). In the Nebraska climate, many prairie grasses specialize in surviving in hot, dry and windy conditions (MacDonagh & Shanstrom, 2015). This makes them ideal candidates for planting on green roofs. In 2009 UNL's Department of Agronomy and Horticulture did a study on different native grasses that would work well in green roof ecosystems. The results of this study found that Bouteloua gracilis (Blue grama) was an excellent candidate for green roof survival in Nebraska (Sutton, 2009). At the University of Nebraska-Lincoln Dr. Richard Sutton also did green roof plant trials for the central Great Plains to test which plants would hold up best to Nebraska's climate conditions. After his trials he found that *Bouteloua dactyloides*, *Carex inops heterophillia* 'SDSU', *Schizachyrium scoparium* 'NCIA', *Distichilis spicata*, *Carex bicknellii*, *Muhlenbergia cuspidata* and *Boutelous hirsuta* are all species that had a 100% survival rate after 4 years of the trial (Sutton, 2015). Ideal green roof plant shouldn't be invasive and should not take intensive management practices to maintain (MacDonagh & Shanstrom, 2015).

Continuing the research that has been done on green roofs in Nebraska is very important for many reasons. Besides the aesthetic and economic benefits to the urban landscape, green roofs can be helpful in mitigating other environmental problems that have surfaced due to global climate change. In Lincoln specifically there are only six green roofs that have been built (Sutton, 2017). This is low in comparison to other cities around the Midwest. In fact, Chicago has more green roofs than any other city in the US with many plans for future expansion (Stutz, 2010). The data collected from Chicago's implementation of green roofs could be very helpful to Nebraska due to the similarity in both states' midwestern climates.

The focus of this project proposes retrofitting a green roof on one of UNL's campuses. There is currently a small green roof on top Keim Hall courtyard tool cabinet and the East Campus Rec Center (Sutton, 2017) but UNL has the potential to expand its use of green roofs. Many college campuses in the Midwest have implemented green roofs including Colorado State University, Iowa State University, the University of Iowa, Western Michigan University, Kansas State University, and Michigan State University to name a few. Michigan State University has shown that there are many added educational benefits that green roofs can have for students. A few of these benefits include providing a teaching and research platform for students as well as being a source for students to engage in hands-on-learning experiences through building and maintaining the green roofs on campus ("MSU Green Roof Research Facilities", 2013).

This proposal will focus on retrofitting a green roof on top of Hardin Hall west entry roof. An estimated cost analysis for retrofitting a green roof onto Hardin Hall was prepared in January 2018. Its estimated that total materials and shipping cost was $21,149.40 (10Sutton, 2018).

This project is important because as we increase knowledge about green roofs and how to make them sustainable and successful, Lincoln will be more likely to implement them into its urban landscape. For example, Denver, Colorado has passed an ordinance to require that all new buildings being built have a green roof or green space incorporated into them ("Green Building Policy Proposal", 2018). This type of legislation is being considered for other cities in the United States, so it is important for research to be done on green roofs in Lincoln so that the city can gain the benefits and be prepared for future green roof legislation.

Methods:

The objective of this study is to find out how UNL would benefit from retrofitting a green roof onto one of their buildings. To conduct this research a systematic literature review approach was taken. Articles were gathered from different literature search engines to reduce the influence of publication bias. Research began by utilizing the University of Nebraska Lincoln's "Encore" search engine, which gives students access to articles published across a wide variety of journal databases. Most of the research for this study was found here because the University provides student access to resources that are otherwise unavailable to the general public. Sources that were referenced in some of the initial articles found on Encore were also utilized in this study whenever relevant. Further research was gathered through correspondence with Dr. Richard Sutton from the University of Nebraska Lincoln. Dr. Sutton has an extensive background in designing, maintaining, and studying green roofs and has published a great deal of literature on the topic. Dr. Sutton was able to provide multiple articles and studies that were helpful to this project including some of his own research into the cost of retrofitting the proposed green roof model.

To find relevant articles key search terms were used. Initially the search term "green roof" was used to get a general idea of what different kinds of studies have been done on the topic. From there the search terms became more focused in order to gather specific information relevant to the objective of the study. Search terms like "green roof energy savings", "green roof urban heat island", "green roof benefits", "green roof cost", "Midwest green roof" and "green roof storm water runoff" were all used. Many articles published by Dr. Sutton were also used because his research was done here in Nebraska making it particularly applicable to this project.

All sources were verified as peer-reviewed and published in a journal, proving they meet the standards of journal publication. Articles were initially analyzed for relevancy through abstract screening and then were further evaluated to make sure the studies done were compatible with what the proposed model green roof would entail. This screening was done by myself and in some cases Dr. Sutton who provided a lot of research for this project. Having Dr. Sutton do some of the initial screening of the sources and then also screening them myself allowed for highly relevant articles from a variety of sources to be chosen for this project.

After articles and publications were chosen data extraction began. This included gathering data from different studies and comparing them to find patterns and themes. For specific data on how green roofs reduce temperature fluctuation and reduce heating and cooling utility costs, a qualitative systematic review system was used. Data was compared across different studies and utilized to help make predictions and models for the sample green roof.

To analyze annual predicted energy performance of a green roof in Lincoln, compared to typical black or white covered roofs the "Green Roof Energy Calculator" was used (Arizona State University, 2007). This energy calculator was funded by the University of Toronto, Portland State University, and Environment and Climate change Canada. Currently, it is being maintained by Julie Ann Wrigley of the Global Institute of Sustainability at Arizona State University. The energy calculator was created based on simulations done by Portland State University that surveyed two different green roof "benchmark buildings" provided by the department of energy (Arizona State University, 2007). They then took site information, utility rates, and precipitation data from 100 North American cities to be used in their model. They used a total of 8,000 different simulations from the 100 cities, data gathered from office and residential buildings, 20 different roof types and 9 distinct green roof models to create a calculator that is able to accurately model green roof energy usage.

All of the data collected was then coded for themes and organized into categories. The themes that emerged were energy cost savings, heat transfer through green roof data, storm water mitigation, and the different benefits of green roofs (both for the private owner and for the surrounding environment). The themes found in the systematic literature review were then used to create the proposal to UNL about why retrofitting green roofs onto buildings on campus would offer many benefits to the University.

Literature Review:

Benefits to the Environment

Adding green roofs to urban spaces has a positive contribution on the surrounding environment. The plants on the roof are able to absorb sunlight instead of converting it straight into heat energy like a plain black roof would ("About Green Roofs," n.d.). This, along with the evapotranspiration cycles of plants, reduce the Urban Heat Island (UHI) effect in cities. The plants are also able to trap airborne pollutants and photosynthesize to improve the air quality in cities ("About Green Roofs," n.d.; Sutton, 2015b). Green roofs can also be designed to support an ecosystem for various bird species or pollinators ("About Green Roofs," n.d.; Sutton, 2015b) in areas that are urbanized and don't have an established habitat for them.

Storm water Runoff Mitigation

Green roofs have the ability to slow the amount of storm water that runs off into city sewer systems by storing storm water in their substrate layer. Through the processes of water being stored in the substrate layer, then taken up by plants and finally being released through transpiration and evaporation, green roofs are able to slow the amount of water runoff during storms. Green roofs are able to retain 70-90% of storm water that falls on them in the summer and anywhere from 25-40% in the winter ("About Green Roofs," n.d.). Green roofs are able to decrease the strain on sewer systems during a storm by delaying and reducing the amount of water that hits the systems ("About Green Roofs," n.d.).

Benefits to owners of green roofs

Throughout the day, especially in the summer, roofs experience large temperature fluctuations and ultraviolet light radiation. This thermal stress reduces the long-term performance of the roof (Liu & Minor, 2005). Green roofs prolong the life of the roof by protecting the roof membrane from ultraviolet light degradation and small tears on the membrane that result from cyclical heating and cooling (Sutton, 2015b). Average roofs have a lifespan of about 20 years but research has shown that retrofitting a green roof can potentially double the life of roof (Sutton, 2015b). This will decrease the maintenance cost for the owner and will also reduce the amount of waste that goes to the landfill from tearing off and completely replacing the roof's membrane. Besides prolonging the life of the roof green roofs can also increase the buildings marketability ("About Green Roofs," n.d.). This is especially important now that cities like Denver, Colorado are implementing legislation that requires green roofs to be incorporated onto all new buildings ("Green Building Policy Proposal", 2018). Studies have also shown that in offices with green roofs there is a reduction in employee fatigue and an increase in production for office workers that get to look out over the gardens (Sutton, 2015b). Finally green roofs are able to reduce temperature fluctuations throughout the day that helps to reduce the heating and cooling costs of the buildings they're built on.

How Green Roofs Decrease Temperature Fluctuations of Roof

The presence of soil, plants and water on a green roof give it unique thermal properties when compared to typical roofs. Conduction, convection, radiation, and evapotranspiration are all components of heat transfer and storage in a green roof (Becker

& Wang, 2011). The plant and substrate barrier have low thermal conductivities and reduce the amount of heat transferred from high temperatures outside the roof down into the air conditioned space below the roof (Becker & Wang, 2011). The presence of water in the substrate and drainage layer also reduces the amount of heat transferred through convection (Becker & Wang, 2011). As solar radiation hits the green roof plants they are able to absorb the heat instead of reflecting it the way a standard black covered roof would (Becker & Wang, 2011). And finally when plants take in water and evapotranspire it cools the air surrounding the roof (Becker & Wang, 2011). All of these factors reduce the amount of heat that is transferred into the air-conditioned space below on a hot summer day. These factors also reduce the amount of heat that escapes a building through the roof on a cold winter day. The drainage, substrate, and vegetative layer add thermal mass (the ability to store heat) to the roof system that allows it to delay heat transfer from the outside air to the inside of the building (Parizotto & Lamberts, 2011). In the winter when the growing medium becomes frozen the insulation value decreases meaning green roofs are less efficient at preventing heat transfer in cold months (Liu & Minor, 2005).

Amount of Reduction in Heat Transfer Resulting From Green Roof

Much research has tried to quantify exactly how much green roofs are able to reduce heat transfer for buildings. When green roofs are compared to different reference roofs (standard black covered, metallic, shingled, and ceramic) they were able to reduce the peak roof temperature anywhere from 18.1°C (Parizotto & Lamberts, 2011) up to 28°C (Liu & Minor, 2005) in the summer months. They've also found that the green roof delayed and reduced heat transfer through the roofing system from 15 W/m2 to less than

2.5 W/m2 (Liu & Minor, 2005). Diurnal temperature fluctuation is the difference from the maximum and minimum daily temperature of a roof membrane (Liu & Minor, 2005). Green roofs have been shown to reduce diurnal temperature fluctuations from over 50°C to about 10°C (Liu & Minor, 2005). It was also found that green roofs were able to reduce heat flow through the roof by 70-90% in the summer (Liu & Minor, 2005; Parizotto & Lamberts, 2011; Becker & Wang, 2011). During the hottest times of the day a study done by Celik et al. in 2019 showed that green roofs decreased the average temperature under the roof from 21.7°C on the reference roof to 15.1°C (Celik et al., 2019). These reductions in heat flow from the air outside the roof to the internal building below help to reduce the stress on cooling systems in the summer months. These results are modeled in Table 2 below.

In the winter green roofs also reduce the amount of heat loss from the roofs of buildings. Becker & Wang in 2011 found that on average 26% less heat was lost from the green roof when compared to their concrete covered reference roofs (Becker & Wang, 2011). Liu and Minor in 2005 found that green roofs reduced heat loss by 10-30% in the winter when compared to a black covered roof and Parizotto and Lamberts in 2011 found they reduced heat loss by 44-52% when compared to ceramic and metallic roofs (Parizotto & Lamberts, 2011). These results are modeled in Graph 1 below.

Results

UNL has a plan for re-roofing buildings annually. Based off this schedule UNL could choose to retrofit a green roof onto these buildings instead of replacing the existing roof with loose laid black (or even white) EPDM roofing membrane. UNL currently uses a loose laid system that is a layer of plastic roofing membrane covered with rock ballast to hold the plastic membrane in place. These roofs are already designed for the structural load of the rocks so they would be able to support the weight of a green roof system.

Retrofitting a semi-intensive green roof system with 6 inches of crumb rubber media instead of re-roofing with EPDM would benefit UNL. Native prairie grasses make the best candidates for this proposed green roof system because they are wind and drought tolerant and have adapted to Nebraska's climate. *Bouteloua dactyloides, Carex inops heterophillia* 'SDSU', *Schizachyrium scoparium* 'NCIA', *Distichilis spicata, Carex bicknellii*, *Muhlenbergia cuspidata* and *Boutelous hirsuta* are all prairie grasses that have had 100% survival rate after 4 years in trials done on green roofs in Nebraska (Sutton, 2015). These low maintenance species take and will survive without an irrigation system being implemented into the green roof. This will decrease the overall cost of maintaining the green roof. Because this model uses prairie grasses initially there may need to be a sprinkler that can be put up on the roof to help get the grasses established. Once established the plantings would require irrigation a few times a growing season. The grasses won't need much maintenance and will only need to be mowed once in the spring every 1 to 2-years.

This green roof system has been modeled for Hardin Hall's west entrance overhang. This location was chosen because it's a low vulnerability area and it's only one story off the ground making it easily accessible. This proposed model can be implemented onto many different roofs around campus and is meant to be a demonstration of how a green roof could benefit UNL.

Based off the cost analysis done by Dr. Richard Sutton in 2018 for this green roof system would cost $10.25 per square foot to implement with the total cost for the 2,063 square foot roof being $21,149.40 (9?Sutton, 2018). This cost analysis includes the cost of all components necessary to build a green roof system as well as their shipping cost, but does not account for labor. UNL typically spends $14.50-$18.50 per square foot to re-roof it's buildings according to Barry Christensen who works for the university's Facilities Planning and Construction department.

Arizona State maintains a "Green Roof Energy Calculator" where inputs like city, total area of roof, type of building, growing media depth, leaf area index, whether the roof is irrigated, the percent the green roof covers, and finally what type of covering is used on the remaining portion of the roof. Different calculations were done for an "old office building" and a "new office building" in Omaha, Nebraska. This calculator does not provide data for Lincoln, Nebraska but the cities are close enough in proximity and climate that for this study the results will be relevant. Also it was assumed that the roof was over usable, heated and cooled space. In such a case, Table 1 shows different inputs and result from three different trials using the Green Roof Energy Calculator. For these trials the 2063 ft^2 roof area on the Hardin Hall overhang was tested. For each trial the growing media depth was input as 6-inches with no irrigation. The green roof is assumed to cover 80% of the total roof area in all trials. Leaf area index was calculated based off of a study done by He, Guo, and Wilmshurst in 2007 that studied different prairie grasses and found an average leaf area index to be 1.3 (He et al., 2007). These inputs remained constant while "old" or "new" office building changed. The new office building trial is to simulate the results if UNL were to choose to incorporate a green roof onto a newly built building. The remaining roof covering was also changed with two trials based off black roof covering and one trial based off white roof covering. UNL uses black roof coverings on most buildings but also has some buildings with white rooftops. Throughout these trials total annual energy savings was highest when comparing the green roof to a dark albedo covered roof. The trial done on a new office building roof had the highest energy cost savings at $98.06 annually compared to a dark roof and $75.15 compared to a white roof. For old office buildings with these criteria that had a white roof, green roofs performed better than when compared to a roof with dark covering. These results combine energy and gas savings based off of energy cost rates for the Omaha area.

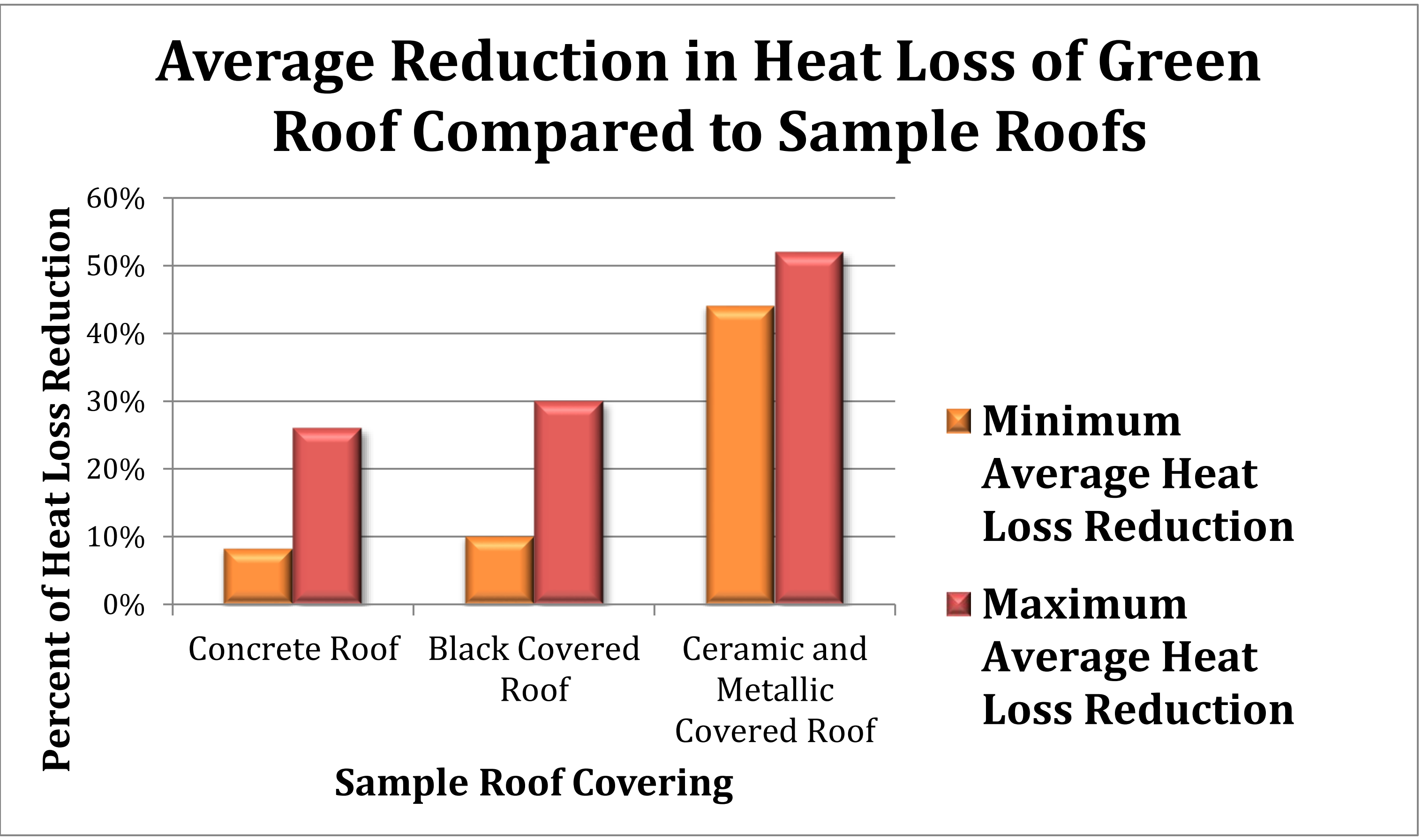
UNL has adopted a sustainable design policy that meets the Leadership in Energy and Environmental Design (LEED) Silver standard. LEED is a building certification program that sets standards for energy performance, water conservation, and indoor air quality in buildings ("University of Nebraska Sustainable Design Policy", 2009). UNL adopted this policy back in 2009 and has used these standards on many renovation projects and new building designs. UNL also earned a Bronze rating in the Sustainability Tracking Assessment and Rating System (STARS) back in 2014 ("University of Nebraska-Lincoln Scorecard", 2019). This rating is based on a college's sustainability curriculum and research, campus engagement, sustainable planning, and how the campus operates sustainably like having recycling programs or sustainable dining hall programs ("University of Nebraska-Lincoln Scorecard", 2019). Retrofitting a green roof onto different buildings around campus would improve UNL's scores for both of these rating systems.

Table 1: Results of potential energy savings green roofs could provide based off data provided by the Green Roof Energy Calculator (Arizona State University 2007).

Total Area of Roof (ft^2) *	Type of Building	Leaf Area Index	Is Green Roof Irrigated?	% of Roof Covered by Green Roof	What Covering is Used on the Rest of Roof	Total Annual Energy Savings (Compared to Dark Roof)	Total Annual Energy Savings (Compared to White Roof)
2063	Old	1.3	No	80%	Dark (0.15 albedo)	$57.39	$14.03
2063	New	1.3	No	80%	Dark (0.15 albedo)	$98.06	$75.15
2063	Old	1.3	No	80%	White (0.65 albedo)	$66.07	$22.70

Table 2: Comparison of different criteria tested in studies done by (Becker & Wang, 2011), (Liu & Minor, 2005), (Parizotto & Lamberts, 2011), and (Celik et al., 2019).

Criteria Tested	Sample Roof Data	Green Roof Data
Daily Heat Transfer Through Roof	15 W/m2	Less than 2.5 W/m2
Diurnal Temperature Fluctuations	Over 50°C	10°C
Heat Flow Through the Roof (Summer)	N/A	Reduced by 70-90%
Average Temperature Under the Roof at Hottest Point of the Day (Summer)	21.7 °C	15.1 °C



Graph 1: Comparison of how much green roofs are able to reduce the amount of heat lost through the roof top in the winter months when compared to standard roof coverings. Results are drawn form studies done by (Becker & Wang, 2011), (Liu & Minor, 2005), and (Parizotto & Lamberts, 2011).

Discussion

One important factor to consider in looking to the future is how global climate change will affect Nebraska's climate. As climate zones shift and change there will be more stress put on cooling systems in buildings. Green roofs reduce the stress put on these systems while also reducing the amount of heat that is reflected off of their rooftops. Retrofitting green roofs onto urban infrastructure will help cities cope with rising temperatures that result from local urban heat islands or global climate change.

The green roof system proposed here is a model that can be applied to many different buildings around campus. The first year of establishing a green roof can be the hardest so this needs to be taken into account when estimating cost figures. Native prairie grasses, once established, do not take a lot of maintenance or irrigation.

Conclusion

The research done in this project has concluded that retrofitting a green roof onto different buildings around UNL's campuses would be beneficial not only for the University but also for the students and the environment. Student productivity will increase as they have more exposure to nature and are able to look out over green roofs while in class (Sutton, 2015b). Faculty and students will also feel more of a connectedness to nature by seeing green roofs (Sutton, 2014) and the aesthetic beauty of campus could increase.

UNL could also experience a reduction in energy cost from heating and cooling the buildings that have a green roof incorporated onto them ("About Green Roofs," n.d.).

The University would also reduce their maintenance cost by doubling the lifespan of their roofs. UNL could be a leader in green roof research and even implement new classes that students could take that utilize their green roof space. Finally, by implementing this proposed green roof system UNL can increase their LEED and STARS certification ratings making the college not only more environmentally friendly, but also more marketable to future students.

Figure 1:

Project Time Line

Phase	**October**	**November**	**December**	**January**	**February**	**March**	**April**
Data Collection							
Data Analysis							
Make Final Poster							
Write Final Paper							

Proposed Budget

Category	**Details**	**Cost**
Stationery (list items)		$0.00

Printing / Copying		$0.00
Postage		$0.00
Equipment (list items)		$0.00
Travel		$0.00
Laboratory Expenses (list details)		$0.00
Other (list details)		$0.00
	Total Amount Sought	$0.00
Amount Approved by Environmental Studies Director		$0.00
Signature of Director:		

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